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(54) **METHOD OF PRODUCING FUEL DISTRIBUTION PIPE**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

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B21D 53/84	(2006.01)
F02M 63/00	(2006.01)
F02M 55/02	(2006.01)

(52) **U.S. Cl.**

CPC ***F02M 63/00*** (2013.01); ***B21D 53/84*** (2013.01); ***B21K 3/00*** (2013.01); ***F02M 55/025*** (2013.01); *Y10T 29/49231* (2015.01)

(58) **Field of Classification Search**

CPC B21D 53/84; B21K 1/00; B21K 3/00; Y10T 29/49231; F02M 55/025; F02M 63/00

See application file for complete search history.

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

EP	1 273 794	1/2003
EP	2 151 572	2/2010
EP	2 497 938	9/2012
GB	2 416 373	1/2006
JP	2001-329930	11/2001
JP	2011-052554	3/2011

OTHER PUBLICATIONS

Extended European Search Report issued Apr. 7, 2014 in corresponding European Patent Application No. 13002143.9.

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(57) **ABSTRACT**

A method of producing a fuel distribution pipe includes providing a forged bar made of metal, forming a main bore in the forged bar so as to extend along an axial direction of the forged bar, forming an injector bore having an injector opening in the forged bar, forming a bolt through hole having a bolt opening in the forged bar, obtaining a base pipe having the main bore, the injector bore and the bolt through hole from the forged bar, and bending the base pipe such that the injector opening of the injector bore and the bolt opening of the bolt through hole are provided along a line parallel to the axis of the main bore. The injector bore directly communicates with the main bore and the bolt through hole does not communicates with the main bore.

12 Claims, 6 Drawing Sheets

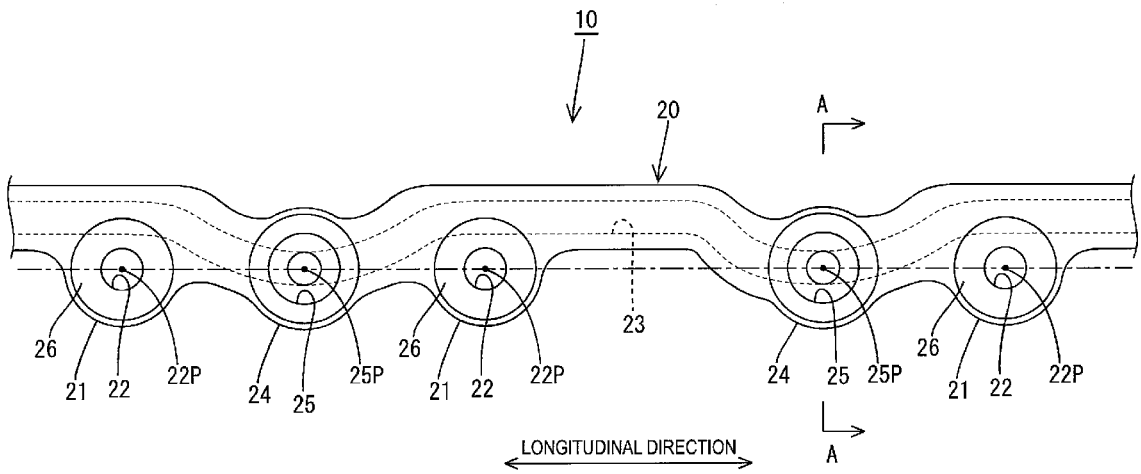


FIG.1

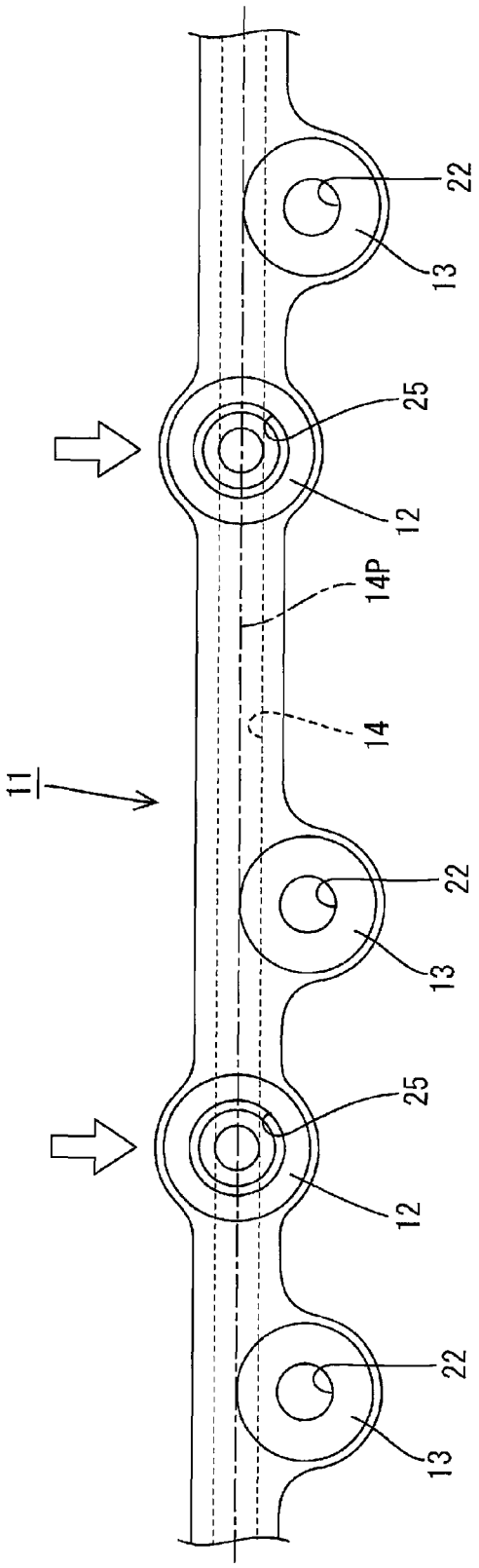


FIG.2

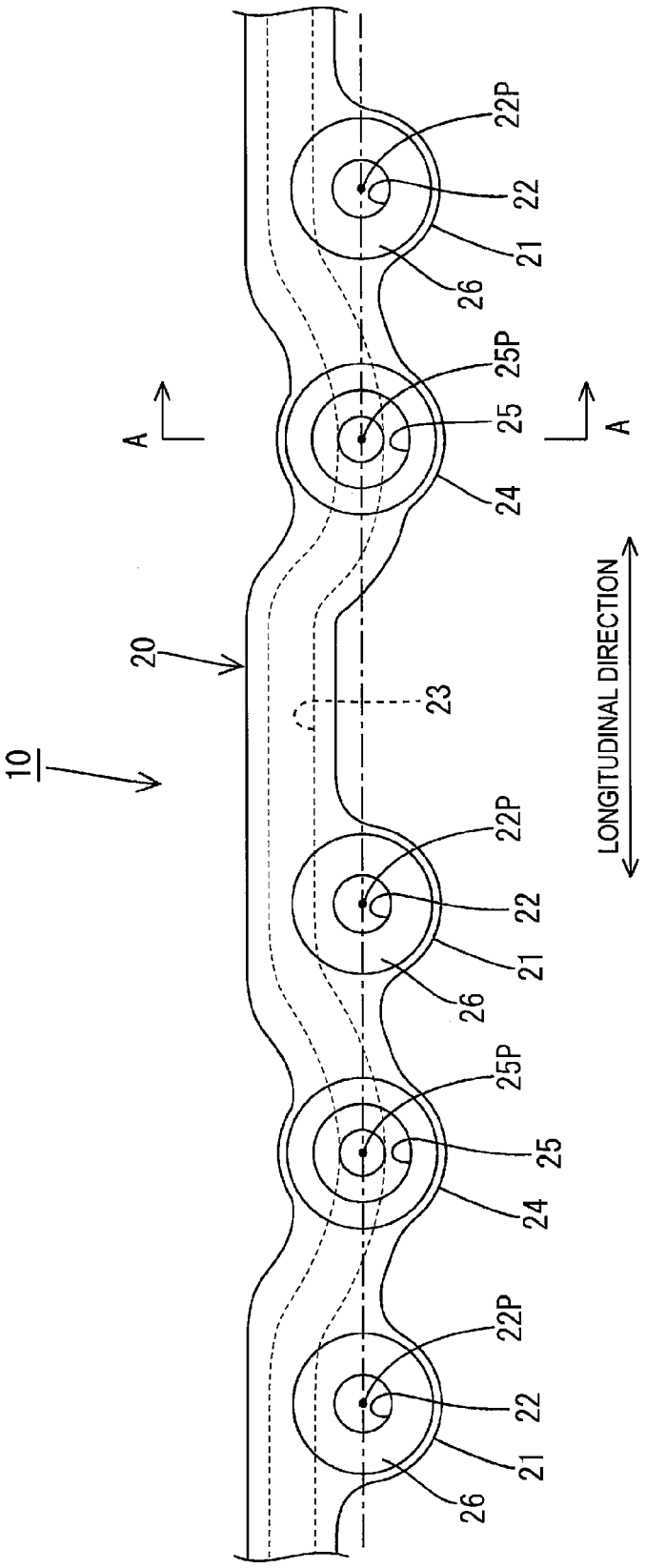


FIG.3

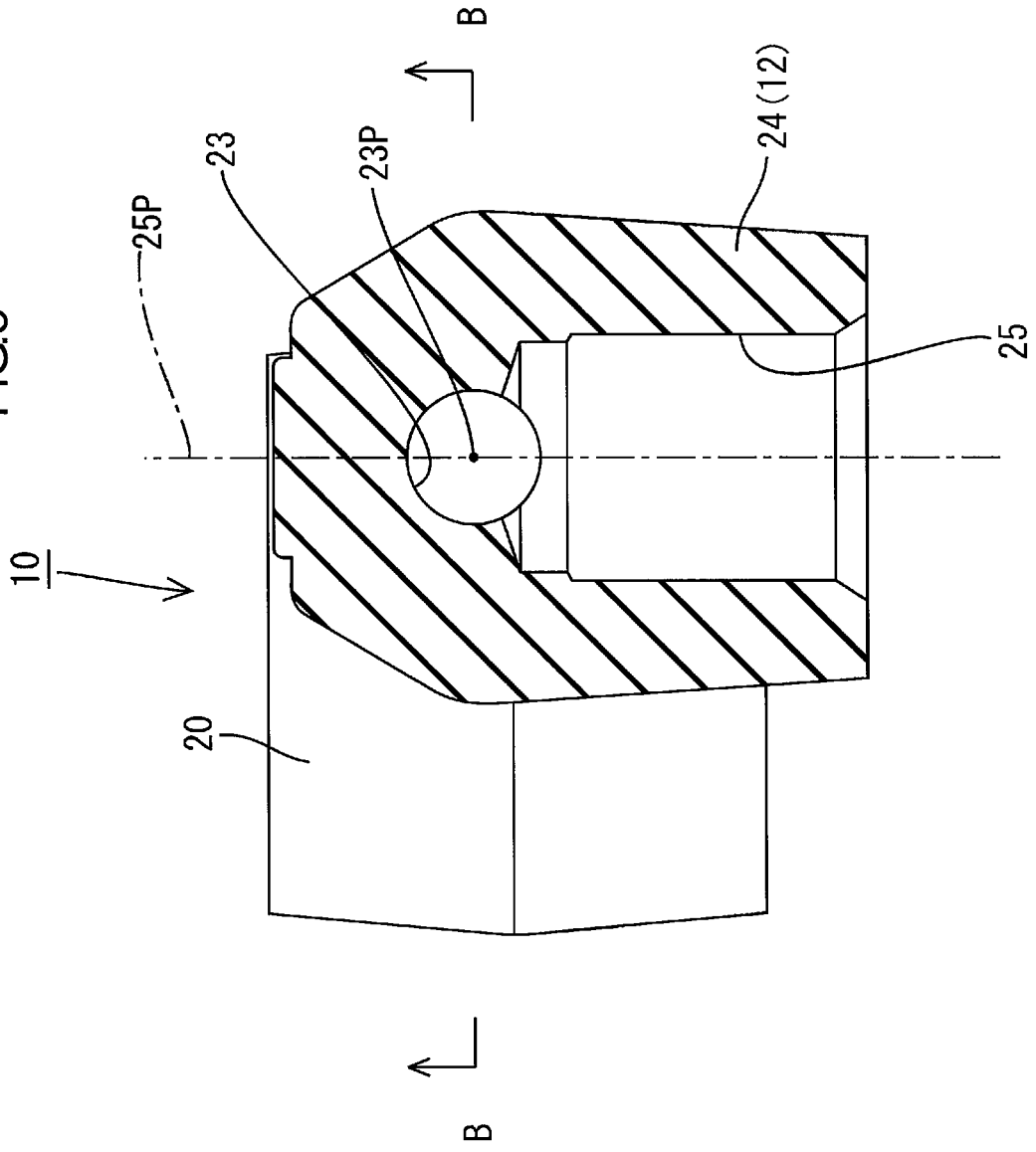


FIG.4

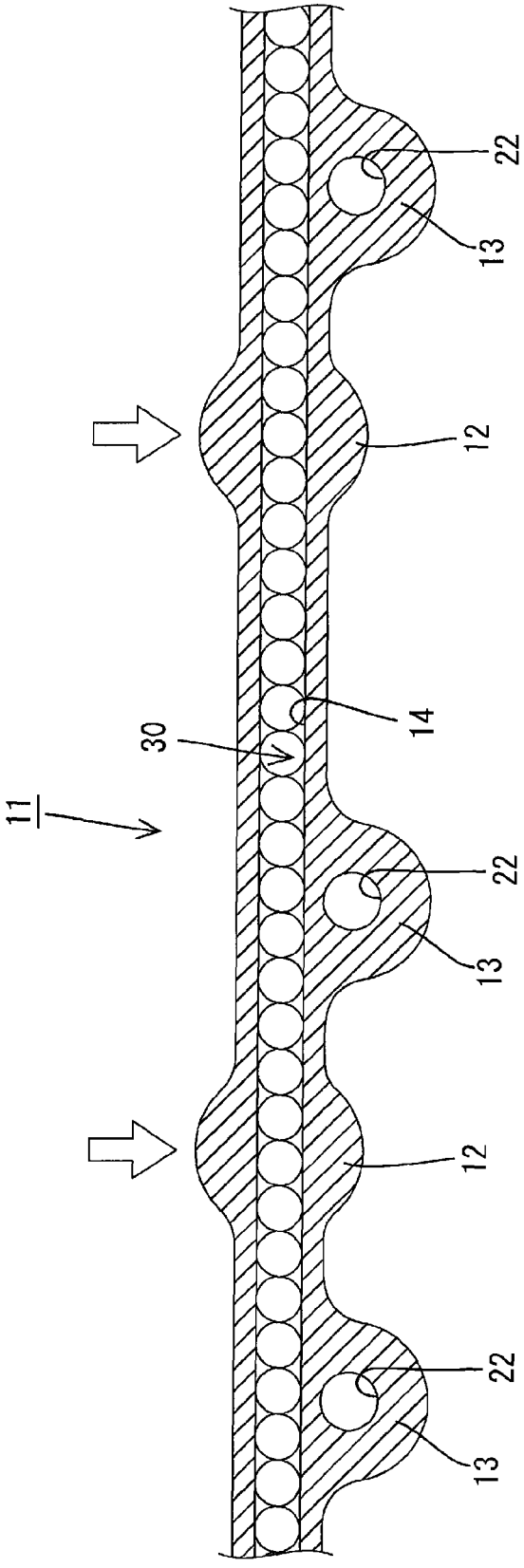


FIG.5

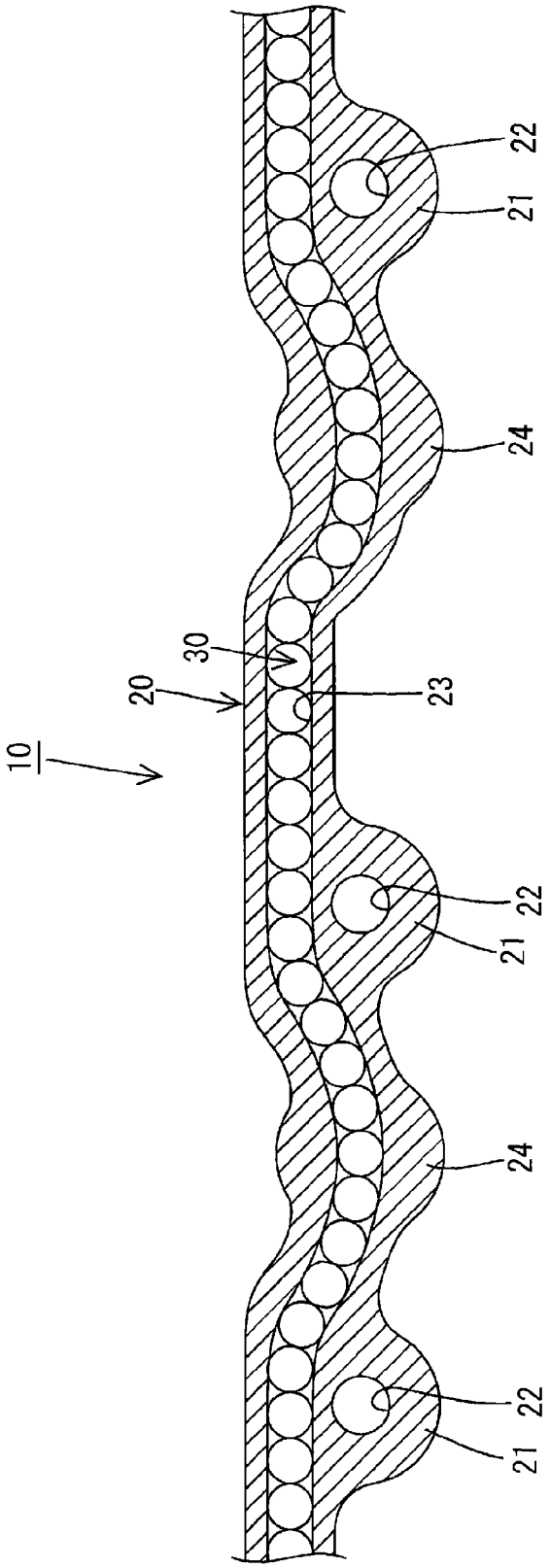
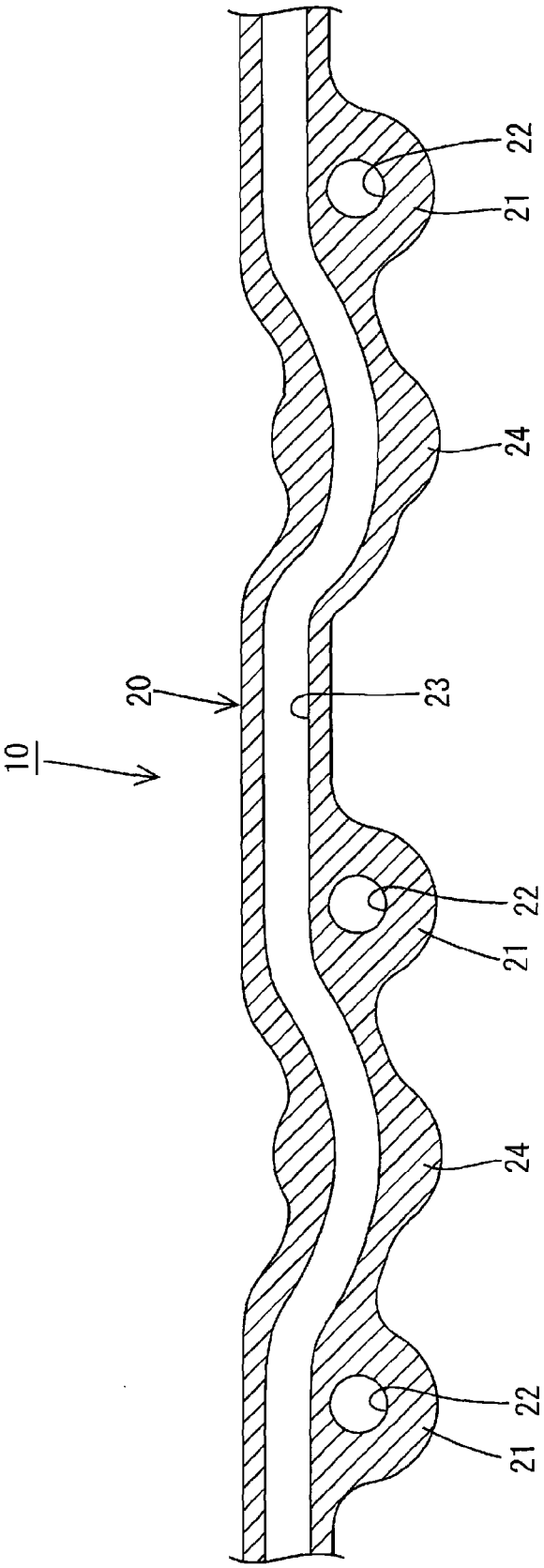


FIG.6



METHOD OF PRODUCING FUEL DISTRIBUTION PIPE

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from Japanese Patent Application No. 2012-117436 filed on May 23, 2012. The entire contents of the priority application are incorporated herein by reference.

FIELD OF THE INVENTION

The present disclosure relates to a method of producing a fuel distribution pipe.

BACKGROUND OF THE INVENTION

For example, a known fuel distribution pipe used in an internal-combustion engine includes a pipe, a bolt attachment portion, and an injector attachment portion. The pipe includes a pipe bore through which fuel flows. The pipe is fixed to a cylinder head with a bolt that is passed through a bolt through hole of the bolt attachment portion. The injector attachment portion includes an injector bore that communicates with the pipe bore. An injector is attached to the injector attachment portion such that the fuel can be supplied from the pipe to the injector through the injector bore.

SUMMARY OF THE INVENTION

A technology described herein relates to a method of producing a fuel distribution pipe to be attached to a cylinder head. The method includes providing a forged bar made of metal, forming a main bore in the forged bar so as to extend along an axial direction of the forged bar, forming an injector bore having an injector opening in the forged bar, forming a bolt through hole having a bolt opening in the forged bar, obtaining a base pipe having the main bore, the injector bore, and the bolt through hole from the forged bar, and bending the base pipe such that the injector opening of the injector bore and the bolt opening of the bolt through hole are provided along a line parallel to the axis of the main bore. Fuel is allowed to flow through the main bore. The injector bore directly communicates with the main bore. The injector bore is configured to receive an injector therein through the injector opening. The bolt through hole does not communicate with the main bore. A bolt is passed through the bolt through hole to fix the pipe to the cylinder head.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a bottom view of a base pipe.

FIG. **2** is a bottom view of a fuel delivery pipe produced according to a method of the present technology.

FIG. **3** is a cross-sectional view taken along a line A-A in FIG. **2**.

FIG. **4** is a cross-sectional view of the base pipe including a main bore in which a diameter retaining member is provided.

FIG. **5** is a cross-sectional view of the base pipe in FIG. **4** that is bent at the injector attachment portion.

FIG. **6** is a cross-sectional view taken along a B-B line in FIG. **3** and illustrating the base pipe in which the diameter retaining member is removed from the base pipe illustrated in FIG. **5**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the above-described related art, the injector bore intersects with the pipe bore, but the bolt through hole does not intersect with the pipe bore and is located outwardly away from the pipe bore. In such a configuration, if a reaction force is applied to the pipe from the cylinder side at the time of injection, a force is generated to rotate the pipe on the bolt attachment portion. This may cause an uplift of the pipe. This problem may be solved by providing the bolt attachment portion and the injector attachment portion such that axes thereof intersect with a line that is parallel to a longitudinal direction of the pipe. Accordingly, a rotation force around the bolt bore is not generated and the uplift of the pipe is less likely to occur.

To obtain the fuel distribution pipe having such an arrangement of the bolt attachment portion and the injector attachment portion, the injector bore may be provided to intersect with the longitudinal direction extending through the bolt bore. However, since the bolt bore does not intersect with the pipe bore, the injector bore does not intersect with the pipe bore. Thus, a communication hole is necessary to be formed to communicate the injector bore and the pipe bore. In the formation of the communication hole, a drilling from an inside of the bore of the injector attachment portion in a diagonal direction is required. This lowers productivity and workability. In addition, the formation of the communication hole may generate a burr at an intersection between the communication hole and the pipe bore. This burr may not be easily visible from an opening of the injector bore, because the intersection is located at the most remote end of the communication hole from the opening of the injector bore. Accordingly, the burr may be difficult to be removed.

A method according to the present technology and a fuel distribution pipe produced by the method will be explained with reference to FIGS. **1** to **6**. Herein, a fuel delivery pipe **10** is used as one example of the fuel distribution pipe produced by the method. Fuel is supplied from a fuel tank in an automobile to the fuel delivery pipe **10** and the fuel delivery pipe **10** distributes the fuel to injectors.

As illustrated in FIG. **2**, the fuel delivery pipe **10** includes a tubular pipe **20**. The pipe **20** includes a plurality of bolt attachment portions **21** and a plurality of injector attachment portions **24**. The bolt attachment portions **21** each includes a bolt through hole **22** extending through the bolt attachment portion **21**. The pipe **20** is fixed to a cylinder head with a bolt (not illustrated) that is passed through the bolt through hole **22**.

The pipe **20** has a pipe bore **23** extending along its axial direction. The pipe bore **23** includes a straight section and a curved section in which the pipe bore **23** extends straightly and curvedly, respectively. The pipe bore **23** and an injector bore **25**, which will be described later, communicate with each other at the curved section. Herein, a direction extends parallel with an axis of a main bore **14** of a base pipe **11**, which will be described later, is referred to as a longitudinal direction. The longitudinal direction corresponds to a right-left direction in FIGS. **1** and **2**. The pipe bore **23** is closed at one end thereof in the longitudinal direction and has an opening at the other end thereof. The pipe **20** is connected to a pipe of the fuel tank at the opening.

The pipe **20** includes the injector attachment portions **24** and an injector is attached to each of the injector attachment portions **24**. The number of the injector attachment portions **24** corresponds to that of the cylinders. Each of the injector attachment portions **24** is located between adjacent two of the

bolt attachment portions **21** in the longitudinal direction. The adjacent two bolt attachment portions **21** are arranged such that at least one of them is located adjacent to the injector attachment portion **24** in the longitudinal direction.

As illustrated in FIG. **3**, the injector attachment portion **24** has a hollow cylindrical shape as a whole and has an injector bore **25** extending along its axis. The injector attachment portion **24** has an opening at one end that is a lower end in FIG. **3**. The other end of the injector attachment portion **24** configures a part of an outer peripheral surface of the pipe **20**. The injector bore **25** is directly connected to the pipe bore **23** to communicate with each other with at a remote end from the opening.

An injector is inserted into the injector bore **25** from the opening of the injector attachment portion **24**. The injector is a fuel injection device that injects fuel into the cylinder of an engine. The fuel supplied to the pipe bore **23** is distributed to the injectors through the injector bores **25**. Then, the injectors inject the fuel to the cylinders of the engine.

The axis **23**P of the pipe bore **23** intersects with the axis **25**P of the injector bore **25** at a right angle, and thus the pipe bore **23** and the injector bore **25** are directly connected to communicate with each other. Accordingly, a communication hole that connects the pipe bore **23** and the injector bore **25** is not required.

As illustrated in FIG. **2**, an opening of the through hole **22** and an opening of the injector bore **25** are provided on a line parallel to the longitudinal direction of the pipe **20**. The axis **22**P of the bolt through hole **22** and the axis **25**P of the injector bore **25** are intersect with a line parallel to the longitudinal direction of the pipe **20**. In other words, when the pipe **20** is viewed along its longitudinal direction, the axis **22**P of the bolt through hole **22** and the axis **25**P of the injector bore **25** are overlapped with each other. Also, a center of the bolt through hole **22** and a center of the injector bore **25** are provided on a line parallel to the longitudinal direction of the pipe **20**. In addition, when the pipe **20** is viewed along a direction perpendicular to the longitudinal direction, the bolt attachment portions **21** and the injector attachment portions **24** are alternately arranged in the longitudinal direction.

In this configuration, the opening of the bolt through hole **22** and the opening of the injector bore **25** are provided on the line parallel to the longitudinal direction of the pipe **20**. Each of the axis **22**P of the bolt through hole **22** and the axis **25**P of the injector bore **25** intersects with the longitudinal direction and intersects with a line parallel to the longitudinal direction. The center of the bolt through hole **22** and the center of the injector bore **25** are provided on the line parallel to the longitudinal direction of the pipe **20**. Accordingly, even if a reaction force from the cylinder side is applied to the pipe **20** through the injector attachment portion **24** at the time of injection of the fuel, a force to rotate the pipe **20** about the bolt through hole **22** is hardly generated. Therefore, the uplift of the pipe **20** is less likely to occur.

As illustrated in FIG. **3**, the axis **25**P of the injector bore **25** intersects with the axis (a center) **23**P of the pipe bore **23** at a right angle, and thus the injector bore **25** and the pipe bore **23** are directly connected to communicate with each other. On the other hand, as illustrated in FIG. **2**, the bolt through hole **22** does not communicate with the pipe bore **23**. The bolt attachment portion **21** is obtained by forming the bolt through hole **22** extending through an extended portion **13** of the pipe **20**. The extended portion **13** continuously extends in a lateral direction (in a lower direction in FIG. **1**) from the pipe. In this configuration, the fuel flowing in the pipe bore **23** does not leak from the bolt through hole **22**, which does not communicate with the pipe bore **23**. The bolt attachment portion **21** includes a receiving surface **26** of the bolt at a portion around an opening of the bolt through hole **22**.

The fuel delivery pipe **10** produced by the method according to the present technology has the above-described configuration. Next, the method of producing the fuel delivery pipe **10** is explained.

Initially, a forged bar that is formed in substantially a tubular shape is provided as a base material for the pipe **20**. The forged bar is made of an iron material such as carbon steel material. The forged bar includes the cylindrical extended portion **13** extending in a direction perpendicular to the longitudinal direction, i.e., in a lower direction in FIG. **1**, and a cylindrical protruded portion **12** extending in a lower direction in FIG. **3**. The forged bar is machined with a drill or a milling machine to obtain a base pipe **11** as illustrated in FIG. **1**. Specifically, the forged bar is drilled along its axis to obtain a main bore **14**. The main bore **14** corresponds to the pipe bore **23** of the fuel delivery pipe **10**. The protruded portion **12** of the forged bar is drilled from a lower end thereof along its axis to obtain the injector bore **25** that communicates with the main bore **14** (see FIG. **3**). The extended portion **13** of the forged bar is drilled along its axis to obtain the bolt thorough hole **22** that does not communicate with the main bore **14**. The inner wall of the bolt through hole **22** is away from the inner wall of the main bore **14** by at least 3 mm.

As illustrated in FIG. **3**, the forged material is drilled at a right angle with respect to the axis **14**P of the main bore **14** to obtain the injector bore **25**. Thus, a step to form a diagonal communication hole is not required. This improves the productivity and workability. In addition, an intersection between the main bore **14** and the injector bore **25** is positioned at a most remote end of the injector bore **25** from its opening, and thus the intersection is easily visible. This facilitates deburring, even if a burr is formed at the intersection.

Then, as illustrated in FIG. **4**, a diameter retaining member **30** is inserted into the main bore **14** of the base pipe **11**. The diameter retaining member **30** has an outer diameter that is substantially equal to an inner diameter of the main bore. The diameter retaining member **30** includes a plurality of metal balls. The metal balls are connected in a displaceable manner relative to each other through a link, for example. The base pipe **11** holding the diameter retaining member **30** in the main bore **14** is pressed in a direction perpendicular to the longitudinal direction of the main bore **14** at the injector attachment portion **24**. The base pipe **11** is pressed until the axis of the injector bore **25**P intersects with a line parallel to the longitudinal direction that passes through the axis of the attachment bore **22**P. The base pipe **11** is pressed in the direction indicated by two outlined arrows in FIG. **4**. As illustrated in FIG. **5**, this converts the main bore **14** of the base pipe **11** to the pipe bore **23** of the pipe **20**. In this state, as illustrated in FIG. **2**, each of the axis **22**P of the bolt through hole **22** and the axis **25**P of the injector bore **25** intersects with the line parallel to the longitudinal direction of the pipe **20**. Namely, the center of the bolt through hole **22** and the center of the injector bore **25** are provided on the line parallel to the longitudinal direction of the pipe **20**. Subsequently, the diameter retaining member **30** is removed from the pipe bore **23**. As illustrated in FIG. **6**, the pipe bore **23** having the same diameter as the main bore **14** is obtained. This method enables the pipe **20** to be formed in any shape.

As described above, according to the method, the bolt through hole **22** and the injector bore **25** are formed in the base pipe **11**, and then the base pipe **11** is pressed at the protruded portion **12** including the injector bore **25**. Thus, the base pipe **11** is bent such that each of the bolt through hole **22** and the injector bore **25** intersects with the line parallel to the

axis of the main bore **14**. Accordingly, the opening of the bolt through hole **22** and the opening of the injector bore are provided on the line parallel to the longitudinal direction of the pipe **20**. Further, the center of the bolt through hole **22** and the center of the injector bore **25** are provided on the line parallel to the longitudinal direction of the pipe **20**. With this configuration, the pipe **20** is hardly rotated upon the injection of fuel. In addition, the axis **25**P of the injector bore **25** and the axis **23**P (the center) of the pipe bore **23** intersect with each other at a right angle. In this configuration, the injector bore **25** and the pipe bore **23** are directly connected to communicate with each other. Thus, even if a burr is generated at the intersection between the injector bore **25** and the pipe bore **23**, the burr can be easily removed.

Other Embodiments

The present invention is not limited to the embodiment as described above with reference to the drawings.

(1) The axis **23**P (the center) of the pipe bore **23** and the axis **25**P of the injector bore **25** may not intersect at a right angle, but may be arranged at any angle on the same plane.

(2) The base pipe may not be bent at the injector attachment portion **24**. The base pipe may be bent at the bolt through hole **22**, or at both of the injector bore **25** and the bolt through hole **22**.

(3) The diameter retaining members is not limited to the metal balls. Any diameter retaining member that can retain diameter of the main bore may be used.

(4) The metal balls of the diameter retaining member **30** may not be connected to each other. Metal balls that are not connected to each other may be used as the diameter retaining member. In such a case, both ends of the main bore **14** may be closed with covers during the bending step.

(4) The forged bar may not be bent by a press. The forged bar may be bent by a forging.

(5) One injector attachment portion **24** may not be located between two bolt attachment portions **21**. Only one bolt attachment portion may be provided for one injector attachment portion.

(6) The fuel delivery pipe may not be the fuel delivery pipe **10** for a gasoline engine. The fuel delivery pipe may be a common rail for a diesel engine.

The invention claimed is:

1. A method of producing a fuel distribution pipe to be attached to a cylinder head,

the method comprising:

providing a forged bar made of metal;

forming a main bore in the forged bar so as to extend along an axial direction of the forged bar, the main bore through which fuel is allowed to flow;

forming an injector bore in the forged bar, the injector bore having an injector opening and directly communicating with the main bore, the injector bore being configured to receive an injector therein through the injector opening;

forming a bolt through hole in the forged bar, the bolt through hole having a bolt opening and not communicating with the main bore, the bolt through hole through which a bolt is to be passed to fix the pipe to the cylinder head;

obtaining a base pipe having the main bore, the injector bore, and the bolt through hole from the forged bar; and

bending the base pipe such that the injector opening of the injector bore and the bolt opening of the bolt through hole are provided along a line parallel to an axis of the main bore.

2. The method of producing a fuel distribution pipe according to claim **1**, wherein the bending step includes bending a portion of the base pipe in which the injector bore is formed such that the injector opening and the bolt opening are provided along the line parallel to the axis of the main bore.

3. The method of producing a fuel distribution pipe according to claim **1**, wherein the base pipe is bent such that an axis of the injector bore and an axis of the bolt through hole intersect with the axis of the main bore of the base pipe.

4. The method of producing a fuel distribution pipe according to claim **1**, wherein the base pipe is bent such that a center of the injector opening and a center of the bolt opening are provided along the line parallel to the axis of the main bore.

5. The method of producing a fuel distribution pipe according to claim **1**, wherein

the forged bar includes an extended portion and a protruded portion,

the extended portion extends away from the main bore and the bolt through hole is formed in the extended portion, and

the injector bore is formed in the protruded portion.

6. The method of producing a fuel distribution pipe according to claim **1**, further comprising:

inserting a diameter retaining member into the main bore of the base pipe before the bending step, the diameter retaining member maintaining a diameter of the main bore during the bending step; and

removing the diameter retaining member from the main bore after the bending step.

7. The method of producing a fuel distribution pipe according to claim **6**, wherein the diameter retaining member has an outer diameter that is substantially equal to an inner diameter of the main bore.

8. The method of producing a fuel distribution pipe according to claim **6**, wherein the diameter retaining member includes a plurality of metal balls connected with each other via a link.

9. The method of producing a fuel distribution pipe according to claim **1**, wherein the forming step of forming the injector bore includes drilling the forged bar at a right angle with respect to the main bore.

10. The method of producing a fuel distribution pipe according to claim **1**, wherein the base pipe is bent such that an axis of the injector bore and an axis of the bolt through hole are parallel with each other.

11. The method of producing a fuel distribution pipe according to claim **1**, wherein the bending step includes pressing the base pipe to be bent.

12. The method of producing a fuel distribution pipe according to claim **1**, wherein

the forming step of forming the bolt through hole includes forming a plurality of bolt through holes, and

the forming step of forming the injector bore includes forming a plurality of injector bores, each of the injector bores being formed between an adjacent pair of the bolt through holes.

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